work has just started. An extension to Holborn has been granted, where (besides connecting with the Central London Railway) it will form a junction with the

(8) *Great Northern and Strand Railway.*—This will run from Finsbury Park (G.N.R.) past King's Cross and Holborn to the Strand.

(9) *Charing Cross, Euston and Hampstead Railway.*—Starting at the Charing Cross end, the line runs to Tottenham Court Road, where it gives a cross connection with the Central London, thence *viâ* Euston to Hampstead (Golder's Green) and Highgate. At the Golder's Green end there is to be a junction with the

(10) *Hampstead and Edgware Railway.*—This is to run in the open to Edgware. The line, which is outside the limits of the map, is to be controlled by the Charing Cross, Euston and Hampstead Railway.

(11) *Baker Street and Waterloo Railway.*—This railway was authorised in 1893. Construction work is now considerably advanced. The line with the extensions granted runs from Paddington (G.W.R.) *viâ* Marylebone (G.C.R.), Baker Street, Oxford Circus, Piccadilly Circus, Charing Cross and Waterloo to the Elephant and Castle, where it connects with the City and South London Railway.

Mr. Yerkes holds a large interest in all the above railways (4–11). Power will be supplied to all (except possibly the two last) from the generating station in Lots Road, Chelsea (4), particulars of which have already been given. The Metropolitan Railway has, however, a separate power station at Neasden.

(12) *London United Railways (Hammersmith and Piccadilly).*—This line, which is promoted by the London United Tramways and half owned by Mr. Morgan, will run under Hammersmith Road, Kensington High Street and Piccadilly to the Circus. At the Hammersmith end it is fed by the tramways. At the Piccadilly end it forms an end-on junction with the

(13) *Piccadilly and City Railway.*—This line is to run from Piccadilly Circus to Charing Cross, and thence under the Strand and Fleet Street to the Bank. At the Bank there is an end-on junction with the

(14) *North-East London Railway.*—This railway runs from the Bank through Highbury and Tottenham to Palmer's Green (near Southgate). The last few miles are to run in the open. This, with the two above lines and the London United Tramways, will give a through route from the extreme west to the north-east of London. Through booking is to be adopted, the proposed fares being extremely small. The group is known as the "Morgan" group, and will be supplied with power from the stations at Fulham (5) and Kingsland (6).

(15) *London United Railways (Marble Arch and Clapham Junction).*—This line gives a south and north connection running from Clapham Junction *viâ* Sloane Street under Hyde Park to Marble Arch. It is promoted by the London United Tramways Company, and will obtain power from the same station as their other railway. At Marble Arch there is connection with the Central London Railway and an end-on junction with the

(16) *North-West London Railway.*—This railway is to run under the Edgware Road to Cricklewood. The line was authorised in 1899, but construction work has not yet started. There are to be stations every half mile.

(17) *Great Northern and City Railway.*—An extension of this railway (which starts at Finsbury Park) to the Bank has been granted. The construction work is nearly completed. The generating station is to be on the Regent's Canal (7).

(18) *City and Brixton Railway.*—This line, which has been leased to the City and South London Railway, runs under the Brixton Road and connects Brixton with the City. Construction work has not yet commenced and details are not available.

(19) *London, Tilbury and Southend Railway.*—Powers have been granted to run the whole of this line electrically, but it is not proposed to do so until necessary. At first only such portions will be converted as are considered necessary to work in with the District Railway electrification. A site, large enough for a generating station for the whole line, has been acquired on the River Roding (a little beyond the limit of the map).

M. S.

THE PITTSBURG MEETING OF THE AMERICAN ASSOCIATION.

THE fifty-first annual meeting of the American Association for the Advancement of Science was held at Pittsburg, Pa., June 28–July 3, 1902, under the presidency of Prof. Asaph Hall, formerly of the United States Naval Observatory, and Harvard University.

The meeting was not a large one, but was attended by many of the leading men of science in the United States. The total registration was 436, and the majority of those in attendance were Fellows. A number of affiliated societies met at the same time and place in connection with the Association. These societies were the Geological Society of America, the American Chemical Society, the Society for the Promotion of Agricultural Science, the Botanical Society of America, the American Microscopical Society, the American Folk-Lore Society, the Association of Economic Entomologists, the Society for the Promotion of Engineering Education, the American Physical Society, the American Anthropological Association and the National Geographic Society. The meetings of these societies were all largely attended and their registration was not included in that of the Association, so that the Pittsburg meeting was practically a gathering of about one thousand scientific men.

As is quite natural, on account of its great mining and manufacturing interests, Pittsburg proved to be an especially attractive meeting-place for the engineers and geologists. The botanical and chemical sections and their affiliated societies were also represented with especial strength.

The address of the retiring president, Dr. Charles Sedgwick Minot, of the Harvard Medical School, was delivered on the evening of July 1 and is printed in full in this number. The other evening functions of the meeting were :—(1) A popular lecture by Dr. Leonard P. Kinnicutt, of the Worcester Polytechnic Institute, on "The Prevention of the Pollution of Streams by Modern Methods of Sewage Treatment." Dr. Kinnicutt is a well-known American expert in this line of work, and has been a careful observer of the experiments which have been and are being made in England, many of his lantern slides referring to English work. (2) On July 3 Mr. Robert T. Hill, of the U.S. Geological Survey, gave an illustrated lecture on the recent volcanic eruptions in Martinique. Mr. Hill was leader of an expedition to Martinique a few days after the eruption of Mont Pelée, other members being Prof. I. C. Russell, of Ann Arbor, Mich., and Commander Borchgrevink. The expedition was sent out by the National Geographic Society.

The vice-presidential addresses were as follows :—

Prof. James McMahon, of Cornell University, before the Section of Mathematics and Astronomy, on the subject "Some Recent Applications of the Function Theory to Physical Problems." Prof. D. B. Brace, of the University of Nebraska, before the Section of Physics, on the subject "The Group Velocity and the Wave Velocity of Light." Prof. H. S. Jacoby, of Cornell University, before the Section of Mechanical Science and Engineering, on the subject "Recent Progress in American Bridge Construction." Dr. B. T. Galloway, of the U.S. Department of Agriculture, before the Section of Botany, on

the subject "Applied Botany—Retrospective and Prospective." Prof. C. R. Van Hise, of the University of Wisconsin, before the Section of Geology and Geography, on the subject "The Training and Work of a Geologist." Prof. David Starr Jordan, of Stanford University, before the Section of Zoology, on the subject "The History of Ichthyology." Dr. J. Walter Fewkes, of the Bureau of American Ethnology, before the Section of Anthropology, on the subject "Prehistoric Porto Rico." Mr. John Hyde, of the U.S. Department of Agriculture, before the Section of Social and Economic Science, on the subject "Some Statistical and Economic Aspects of Preventable Diseases."

Certain important amendments to the constitution were made. The terms of office of secretaries of sections were lengthened from one year to five years. The council was given the power to add to its number nine Fellows whose terms of office shall be three years. The sectional committees were given greater permanency by provision for the election of one member each year who shall serve five years. All the recent changes in the constitution have aimed towards a greater permanency in the executive officers of the Association, of the council and of the sectional committees, and have increased the powers of the council.

The report of the treasurer and the financial report of the permanent secretary show the finances of the Association to be in a prosperous condition, and although they have by no means reached the standing of those of the British Association, the American Association is able this year to devote more funds to research grants. This year grants were made to committees on anthropometric measurements, the study of blind vertebrates, the relations of plants and climate, the atomic weight of thorium, and the determination of the velocity of light.

The next meeting of the Association will be held at Washington, from December 29, 1902, to January 3, 1903. The change in the time of meeting is a very important one and was made only after the most careful consideration. American universities and colleges have lengthened their Christmas holidays so as to enable the members of the scientific faculties to attend such winter meetings, and the week which contains the first day of January each year has been designated as "Convocation Week." Not only will the national scientific societies of the United States meet during this week under the auspices of the American Association, but the other learned societies of the country will also adopt this plan.

The president elected for the Washington meeting is Prof. Ira Remsen, the well-known chemist, recently made president of Johns Hopkins University. The vice-presidents of the different sections will be as follows:—Mathematics and Astronomy, Prof. George Bruce Halsted, of the University of Texas; Physics, Prof. E. F. Nichols, of Dartmouth College; Chemistry, Prof. Charles Baskerville, of the University of North Carolina; Mechanical Science and Engineering, Prof. C. A. Waldo, of Purdue University; Geology and Geography, Prof. W. M. Davis, of Harvard University; Zoology, Prof. C. W. Hargitt, of Syracuse University; Botany, Mr. F. V. Coville, of the U. S. Department of Agriculture; Anthropology, Mr. G. M. Dorsey, of the Field Columbian Museum, Chicago; Social and Economic Science, Mr. H. T. Newcomb, of Philadelphia, editor of *The Railway World*.

At the Washington meeting many additional societies will come into affiliation with the American Association, notably the American Society of Naturalists, with its group of special societies which have always held a mid-winter meeting, namely, the Society of Morphologists, the Society of Anatomists, the Society of Physiologists, the Society of Psychologists, the Society of Bacteriologists, the Society of Plant Morphologists, and others.

ADDRESS BY PROF. C. S. MINOT, PRESIDENT OF THE ASSOCIATION.

The Problem of Consciousness in its Biological Aspects.

OUR Association meets in Pittsburg for the first time. We are glad to indicate by our assembling here our appreciation of the immense work for the promotion of education and science which has been begun in this city and already is of national value. It has been initiated with so great wisdom and zeal that we expect it to render services to knowledge of the highest character, and we are glad to be the guests of a city and of institutions which are contributing so nobly to the cause of science.

We may congratulate ourselves on the bright prospects of the Association. Our membership has grown rapidly, and ought soon to exceed four thousand. Every member should endeavour to secure new adherents. For our next meeting we are to break with the long tradition of summer gatherings and assemble instead at New Year's time, presumably at Washington. To render this possible it was necessary to secure the cooperation of our universities, colleges and technical schools to set aside the week in which the first of January falls as "Convocation Week" for the meetings of learned societies. The plan, owing to the cordial and almost universal support given by the higher educational institutions, has been successfully carried through. For the winter meetings we have, further, succeeded in securing the cooperation of numerous national societies. The change in our time of meeting is an experiment, which we venture upon with the greater confidence because of the success of our present meeting in Pittsburg.

For my address this evening I have chosen the theme, "The Problem of Consciousness in its Biological Aspects." I hope both to convince you that the time has come to take up consciousness as a strictly biological problem, and also to indicate the nature of that problem and some of the actual opportunities for investigating it. It is necessary to begin with a few words on the philosophical interpretation. We shall then describe the function of consciousness in animal life, and consider its part in the evolution of animals and of man. The views to be stated suggest certain practical recommendations, after presenting which I shall conclude by offering an hypothesis of the relation of consciousness to matter and force.

Consciousness is at once the oldest problem of philosophy and one of the youngest problems of science. The time is not yet for giving a satisfactory definition of consciousness, and we must fain content ourselves with the decision of the metaphysician, who postulates consciousness as an ultimate datum or concept of thought, making the brief dictum *cogito, ergo sum* the pivot about which his system revolves. I have endeavoured vainly to discover, by reading and by questioning those philosophers and psychologists whom I know, some deeper analysis of consciousness, if possible, resolving it into something more ultimate.

Opinions concerning consciousness are many, and often so diverse as to be mutually exclusive, but they may be divided into two principal classes. The first class includes all those views which make of consciousness a real phenomenon, the second those views which interpret it as an epiphenomenon. We are, I think, practically all agreed that the fundamental question is, Does or does not consciousness affect directly the course of events? Or stated in other words, Is consciousness a true cause? In short, we encounter at the outset the problem of free-will, of which more later.

The opinion that consciousness is an epiphenomenon has gained renewed prominence in recent times, for it is, so to speak, a collateral result of that great movement of European thought which has culminated in the development of the doctrine of monism. Monism itself is postulated chiefly upon the two greatest discoveries of the nineteenth century, the law of the conservation of energy and the law of the evolution of species. Both laws establish a greater unity in the phenomena of the universe than mankind had previously been able to accept. In the physical world, instead of many forces we now recognise only one force,[1] which assumes various forms of energy, and in the living world we recognise one life, which manifests itself in many types of form. With these two unities in mind, what could be nearer than the thought that the unity goes still deeper,

[1] Force is used throughout this address as more likely to be understood by a general audience. It would be more correct to use "energy" in the sense in which the word is now applied technically in physics.

and that the phenomena of the inanimate or physical and of the living world are fundamentally identical? The progress of physiological science has greatly increased the impetus towards the adoption of this thought as the cardinal dogma of the new faith, because the work of physiologists has been so devoted to the physical and chemical phenomena of life that the conviction is widespread that all vital phenomena are capable of a physical explanation. Assuming that conviction to be correct, it is easy to draw the final conclusion that the physical explanation suffices for the entire universe. As to what is, or may be, behind the physical explanation, complete agnosticism is, of course, the only possible attitude. Such in barest, but I believe correct, outline is the history of modern monism, the doctrine that there is but one kind of power in the universe.

It is evident that monism involves the elimination of two concepts, God and consciousness. It is true that monists sometimes use these words, but it is mere jugglery, for they deny the concepts for which the words actually stand. Now consciousness is too familiar to all men to be summarily cast aside and dismissed. Some way must be found to account for it. From the monistic standpoint there is a choice between two possible alternatives, either consciousness is a form of energy, like heat, &c., or it is merely a so-called epiphenomenon. As there is no evidence that consciousness is a form of energy, only the second alternative is in reality available, and in fact has been adopted by the monists.

It is essential to have a clear notion of what is meant by an epiphenomenon. Etymologically the word indicates something which is superimposed upon the actual phenomenon. It designates an accompanying incident of a process, which is assumed to have no causal relation to the further development of the process. In practice it is used chiefly in regard to the relation of the mind or consciousness to the body, and is commonly employed by those philosophers who believe that consciousness has no causal relation to any subsequent physiological process.

For many years I have tried to recognise some actual idea underneath the epiphenomenon hypothesis of consciousness, but it more and more seems clear to me that there is no idea at all, and that the hypothesis is an empty phrase, a subterfuge, which really amounts only to this: we can explain consciousness very easily by merely assuming that it does not require to be explained at all. Is not that really the confession made by the famous assertion that the consciousness of the brain no more requires explanation than the aquosity of water?

Monism is not a strong system of philosophy, for it is not so much the product of deep and original thinking as the result of a contemporary tendency. It is not the inevitable end of a logical process, because it omits consciousness, but rather an incidental result of an intellectual impulse. Its very popularity betokens its lack of profundity, and its delight in simple formulæ is characteristic of that mediocrity of thought which has much more ambition than real power and accepts simplicity of formularisation as equivalent to evidence. It would seem stronger, too, if it were less defended as a faith. Strong partisans make feeble philosophers.

Consciousness ought to be regarded as a biological phenomenon, which the biologist has to investigate in order to increase the number of verifiable data concerning it. In that way rather than by speculative thought is the problem of consciousness to be solved, and it is precisely because biologists are beginning to study consciousness that it is becoming, as I said in opening, the newest problem of science.

The biologist must necessarily become more and more the supreme arbiter of all science and philosophy, for human knowledge is itself a biological function, which will become comprehensible just in the measure that biology progresses and brings knowledge of man, both by himself and through comparison with all other living things. We must look to biologists for the mighty generalisations to come rather than to the philosophers, because great new thoughts are generated more by the accumulation of observations than by deep meditation. To know, observe. Observe more and more, and in the end you will know. A generalisation is a mountain of observations; from the summit the outlook is broad; the great observer climbs to the outlook while the mere thinker struggles to imagine it. The best that can be achieved by sheer thinking on the data of ordinary human experience we have already as our glorious inheritance. The principal contribution of science to human progress is the recognition of the value of accumulating data, which are found outside of ordinary human experience.

Twenty-three years ago, at Saratoga, I presented before the meeting of this Association—which I then attended for the first time—a paper "On the Conditions to be Filled by a Theory of Life," in which I maintained that before we can form a theory of life we must settle what are the phenomena to be explained by it. So now, in regard to consciousness, it may be maintained that for the present it is more important to seek additional positive knowledge than to hunt for ultimate interpretations. We welcome, therefore, especially the young science of experimental psychology, which, it is gratifying to note, has made a more auspicious start in America than in any other country. It completes the circle of the biological sciences. It is the department of biology to which properly belongs the problem of consciousness. The results of experimental psychology are still for the most part future. But I shall endeavour to show that we may obtain some valuable preliminary notions concerning consciousness from our present biological knowledge.

We must begin by accepting the direct evidence of our own consciousness as furnishing the basis. We must, further, accept the evidence that consciousness exists in other men essentially identical with the consciousness in each of us. The anatomical, physiological and psychological evidence of the identity of the phenomena in different human individuals is to a scientific mind absolutely conclusive, even though we continue to admit cheerfully that the epistemologist rightly asserts that no knowledge is absolute, and that the metaphysician rightly claims that *ego* is the only reality and everything else exists only as *ego's* idea, because in science, as in practical life, we assume that our knowledge is real and is objective in source.

For the purposes of the following discussion we must define certain qualities or characteristics of consciousness. The most striking distinction of the processes in living bodies, as compared with those in inanimate bodies, is that the living processes have an object—they are teleological. The distinction is so conspicuous that the biologist can very often say *why* a given structure exists or *why* a given function is performed, but *how* the structure exists or *how* the function is performed he can tell very imperfectly—more often not at all. Consciousness is only a particular example, though an excellent one, of this peculiarity of biological knowledge; we do not know what it is; we do not know how it functions; but we do know why it exists. Those who are baffled by the elusiveness of consciousness, when we attempt to analyse it, will do well to remember that all other vital phenomena are in the last instance equally and similarly elusive.

In order to determine the teleological value of consciousness we must endeavour to make clear to ourselves what the essential function is which it performs. As I have found no description or statement of that function which satisfied me, I have ventured, perhaps rashly, to draw up the following new description:—

The function of consciousness is to dislocate in time the reactions from sensations.

In one sense this may be called a definition of consciousness, but inasmuch as it does not tell what consciousness is, but only what it does, we have not a true definition, but a description of a function. The description itself calls for a brief explanation. We receive constantly numerous sensations, and in response to these we do many things. These doings are, comprehensively speaking, our reactions to our sensations. When the response to a stimulus is obviously direct and immediate, we call the response a reflex action; but a very large share of our actions are not reflex, but are determined in a far more complicated manner by the intervention of consciousness, which may do one of two things, first, stop a reaction, as, for example, when something occurs calling, as it were, for our attention and we do not give our attention to it; this we call conscious inhibition; it plays a great *rôle* in our lives, but it does not mean necessarily that inhibited impressions may not survive in memory and at a later time determine the action taken; in such cases the potential reaction is stored up. Second, consciousness may evoke a reaction from a remembered sensation and combine it with sensations received at other times. In other words, consciousness has a selective power, manifest both in choosing from sensations received at the same time and in combining sensations received at different times. It can make synchronous impressions dyschronous in their effects, and dyschronous impressions synchronous. But this somewhat formidable sentence merely paraphrases our original description:—The function of consciousness is to dislocate in time the reactions from sensations.

This disarrangement and constant rearrangement of the sensations, or impressions from sensations, which we gather, so that their connections in time are altered, seems to me the most fundamental and essential characteristic of consciousness which we know. It is not improbable that hereafter it will become possible to give a better characterisation of consciousness. In that case the opinion just given may become unsatisfactory and have to yield to one based on greater knowledge. The characteristic we are considering is certainly important, and so far as the available evidence goes it belongs exclusively to consciousness. Without it life would have no interest, for there would be no possibility of experience, no possibility of education.

Now the more we have learned about animals, the better have we appreciated the fact that in them only such structures and functions are preserved as are useful or have a teleological value. Formerly a good many organs were called rudimentary or vestigial, and were supposed to be useless survivals because they had no known function. But in many cases the functions have since been discovered. Such, for example, were the pineal gland, the pituitary body, the suprarenal capsules and the Wolffian body of man, all of which are now recognised to be functionally important structures. Useless structures are so rare that one questions whether any exist at all, except on an almost insignificant scale. It has accordingly become well-nigh impossible for us to imagine consciousness to have been evolved, as it has been, unless it had been bionomically useful. Let us, therefore, next consider the value of consciousness from the standpoint of bionomics.[1]

We must begin with a consideration of the nature of sensations and the object of the reactions which they cause. In the simpler forms of nervous action a force, usually, but not necessarily, external to the organism, acts as a stimulus, which causes an irritation; the irritation produces a reaction. Within the ordinary range of the stimuli to which an organism is subjected the reaction is teleological—that is, it tends to the benefit of the organism. A familiar illustration is the presence of food in the stomach, which produces a stimulus, the reaction to which is manifested by the secretion of the digestive fluid for the purpose of digesting the food. An organism might conceivably be maintained solely by this mechanism, in cooperation with the physical laws, which govern all matter. Life in such an organism would be a succession of teleological processes, essentially mechanical and regulated automatically by the organism. By far the majority of biologists regard plants as essentially conforming to this type of life. Whether they absolutely so conform we do not, of course, yet know.

A sensation involves the interpolation of consciousness between the stimulation and the reaction, and in consequence there is established the possibility of a higher order of adjustment to the external world than can be attained through the teleological reaction to a stimulus. This possibility depends upon the fact that the intervention of consciousness permits an adjustment in accordance, not merely with the immediate sensation, but also and at the same time in accordance with earlier sensations. Thus, for example, the child sees an object, and its reaction is to take hold of the object, which is hot and hurts the child. Later the child sees the object again, and its natural reaction is to take hold of it again; but the child now reacts differently because its consciousness utilises the earlier as well as the present sensation; the previous sensation is dislocated in time and fused with the present sensation, and a new reaction follows. No argument is necessary to establish the obvious conclusion that an organism which has consciousness has an immensely increased scope for its adjustments to the external conditions; in other words, consciousness has a very high value for the organism. It is unnecessary to dwell upon this conclusion, for it will be admitted by everyone, except, perhaps, those who start with the *a priori* conviction that consciousness is an epiphenomenon.

A sensation gives information concerning the external world. Perhaps science has achieved nothing else which has done so much to clarify philosophy as the demonstration that the objective phenomena are wholly unlike the subjective sensations. Light is a series of undulations, but we do not perceive the undulations as such, but as red, yellow and green, or, as we say, colours; the colours give us available information, and we use them as so many labels, and we learn that reactions to these labels may be helpful or hurtful, and so we regulate our conduct. Objectively red, yellow and green do not exist. Similarly with the vibrations of the air, certain of which cause the sensation of sound, which is purely subjective. But the sound gives us information concerning our surroundings which we utilise for our teleological needs, although in nature, external to us, there is no sound at all. Similarly, all our other senses report to us circumstances and conditions, but always the report is unlike the external reality. Our sensations are symbols merely, not images. They are, however, bionomically sufficient because they are constant. They are useful, not because they copy the external reality or represent it, but because, being constant results of external causes, they enable consciousness to prophesy or foresee the results of the reactions of the organism, and to maintain and improve the continual adjustment to the external reality.

The metaphysicians have for centuries debated whether there is any external objective reality. Is it too much to say that the biological study of consciousness settles the debate in favour of the view that the objective world is real?

Consciousness is not only screened from the objective world from which it receives all its sensations, but also equally from immediate knowledge of the body, through which it acts. As I write this sentence I utilise vaso-motor nerves, regulating the cerebral blood currents, and other nerves, which make my hand muscles contract and relax, but of all this physiological work my consciousness knows nothing, though it commands the work to be done. The contents of consciousness are as unlike what is borne out from it as they are unlike what is borne in to it.

The peculiar untruthfulness to the objective, which consciousness exhibits in what it gets and gives, would be perplexing were it not that we have learned to recognise in consciousness a device to secure better adjustment to external reality. For this service the system of symbols is successful, and we have no ground for supposing that the service would be better if consciousness possessed direct images or copies instead of symbols of the objective world.

Our sensory and motor [1] organs are the servants of consciousness, its messengers or scouts, its agents or labourers, and the nervous system is its administrative office. A large part of our anatomical characteristics exists for the purpose of increasing the resources of consciousness, so that it may do its bionomic function with greater efficiency. Our eyes, ears, taste, &c., are valuable because they supply consciousness with data; our nerves, muscles, bones, &c., are valuable because they enable consciousness to effect the needed reactions.

Let us now turn our attention to the problem of consciousness in animals. The comparative method has an importance in biology which it has in no other science, for life exists in many forms, which we commonly call species. Species, as I once heard it stated, differ from one another with resemblance. The difference which resembles we term an homology. Our arm, the bird's wing, the lizard's front leg are homologous. The conception of homology, both of structure and of function, lies at the basis of all biological science, which must be and remain incomprehensible to any mind not thoroughly imbued with this conception. Only those who are deficient in this respect can fail to understand that the evidence is overwhelming that animals have a consciousness homologous with the human consciousness. The proof is conclusive. As regards at least mammals, I think we could safely say as regards vertebrates, the proof is the whole sum of our knowledge of the structure, functions and life of these animals.

As we descend the animal scale to lower forms there is no break, and therefore no point, in the descent where we can say, here animal consciousness ends and animals below are without it. It seems inevitable, therefore, to admit that consciousness extends far down through the animal kingdom, certainly at least as far down as there are animals with sense organs or even the most rudimentary nervous system. It is unsatisfactory to rely chiefly on the anatomical evidence for the answer to our query. We await eagerly results from psychological experiments on the lower invertebrates. A sense organ, however, implies consciousness, and since such organs occur among cœlenterates we are led to assign consciousness to these animals.

The series of considerations which we have had before us lead directly to the conclusion that the development and improvement of consciousness has been the most important—really the dominant—factor in the evolution of the animal series. The

[1] A convenient term, recently gaining favour, for what might otherwise be called the economics of the living organism. Bionomics seems preferable to *ecology*, which some writers are adopting from the German.

[1] And other organs in efferent relations to consciousness.

sense organs have been multiplied and perfected in order to supply consciousness with a richer, more varied and more trustworthy store of symbols, corresponding to external conditions. The nervous system has grown vastly in complexity in order to permit a constantly increasing variety in the time dislocations of sensations. The motor and allied apparatus have been multiplied and perfected in order to supply consciousness with more possibilities of adjustment to external reality, which might be advantageous.

If we thus assign to consciousness the leading *rôle* in animal evolution we must supplement our hypothesis by another, namely, that conscious actions are primary, reflex and instinctive actions secondary; or in other words, that for the benefit of the organism conscious actions have been transformed into reflexes and instincts. Unfortunately, we must rely chiefly on future physiological and psychological experiments to determine the truth of this hypothesis. Its verification, however, is suggested by certain facts in the comparative physiology of the vertebrate nervous system, which tend to show that in the lower forms (amphibia) a certain degree of consciousness presides over the functions of the spinal cord which in mammals is devoted to reflex actions. Its verification is further suggested by the natural history of habits. As we all know, new actions are performed with difficulty, and slowly, but if often repeated they are soon easier and more rapid. If a given reaction to a sensation or group of sensations through consciousness is advantageous to the organism, and the environment is such that the sensation is often repeated, then a habit is formed, and the response becomes more rapid; and often in ourselves we see habits, which arose from conscious action, working almost without the participation of consciousness, and moreover working usefully, because rapidly. The usefulness of conscious reactions is that they are determined, not merely by the present sensation, but also by past sensations; but they have the defect that they are slow. We can readily understand that it would aid an organism to have the quicker reaction substituted, and we thus recognise a valid teleological reason for the replacement of conscious action by habits in the individual, by instincts in the race. The investigation of the evolution of reflexes and instincts is one of the important and most promising tasks of comparative psychology.

A frank, unbiassed study of consciousness must convince every biologist that it is one of the fundamental phenomena of at least animal life, if not, as is quite possible, of all life. Nevertheless its consideration has barely a place in biological science, although it has long occupied a vast place in philosophy and metaphysics. If this address should contribute to a clearer appreciation of the necessity of treating consciousness as primarily a problem for biological research to solve, my purpose will be achieved. In an ideal world philosophers and men of science would be identical; in the actual world there are philosophical men of science and scientific philosophers; but in the main the followers of the two disciplines pursue paths which are, unfortunately, distinct. The philosophical mind is of a type unlike the scientific mind. The former tries to progress primarily by thought based on the data available, the latter seeks to advance primarily by collecting additional data. The consequence of this difference is that philosophy is dependent upon the progress of science, but we who pursue the scientific way can make no greater mistake than to underestimate philosophy. The warning is needed. Data of observation are a treasure and very precious. They are the foundation of our mental wealth, but that wealth consists of the thought into which the data are transmuted. In pleading, therefore, for an increased observational study of consciousness we plead, not merely for science, but equally for philosophy. The scientific progress must come first. Hence we urge the advantage of investigating consciousness in its immediate revelations, which are accessible now. Let us give up the ineffectual struggle to discover the essential nature of consciousness until we can renew it with much larger resources of knowledge.

The psychologists ought now to apply the comparative method on a grand scale. They are just beginning to use it. Years of patient labour must pass by, but the reward will be very great. The psychic life of animals must be minutely observed, the conditions of observation carefully regulated, and the results recorded item by item. The time has passed by for making generalisations on the basis of our common, vague and often inexact notions concerning the habits of animals. Exact experimental evidence will furnish a rich crop of psychological discovery. Scientific psychology is the most backward in its development of all the great divisions of biology. It needs, however, little courage to prophesy that it will bring forth results of momentous importance to mankind. After data have been gathered, generalisations will follow which, it may be hoped, will lead us on to the understanding of even consciousness itself.

The teleological impress is stamped on all life. Vital functions have a purpose. The purpose is always the maintenance of the individual or of the race in its environment. The entire evolution of plants and animals is essentially the evolution of the means of adjustment of the organism to external conditions. According to the views I have laid before you, consciousness is a conspicuous, a commanding factor of adjustment in animals. Its superiority is so great that it has been, so to speak, eagerly seized upon by natural selection and provided with constantly improved instruments to work with. A concrete illustration will render the conception clearer. In the lowest animals, the cœlenterates, in which we can recognise sense organs, the structure of them is very simple, and they serve as organs of touch and of chemical sensation resembling taste. In certain jelly fishes we find added special organs of orientation and pigmented spots for the perception of light. In worms we have true eyes and vision. In vertebrates we encounter the true sense of smell. Fishes cannot hear, but in the higher vertebrates, that is from the amphibians up, there are true auditory organs. In short, both the senses once evolved are improved and also new senses are added. It is perfectly conceivable that there should be yet other senses, radically different from any we know. Another illustration, and equally forcible, of the evolution of aids to consciousness might be drawn from the comparative history of the motor systems, passing from the simple contractile thread to the striated muscle fibre, from the primitive diffuse nunculature of a hydroid to the highly specialised and correlated muscles of a mammal.

It is interesting to consider the evolution of adjustment to external reality in its broadest features. In the lowest animals the range of the possible adjustment is very limited. In them, not only is the variety of possible actions small, but they cover also a small period of time. In animals which have acquired a higher organisation, the adjustments are more complex both because the reactions are more varied and because they cover a longer period of time. Thus the jelly fish depends upon such food as happens to come within its reach, seizing from moment to moment that which it encounters; but a lobster pursues its food, making complicated movements in order to reach and seize it. One can trap lobsters easily; I doubt if one could trap a jelly fish at all. The next great advance is marked by the establishment of communication between individuals of the same species. About this phenomenon we know exceedingly little; the investigation of it is one of the most important duties of the comparative physiologist. Its bionomic value is obviously great, for it allows an individual to utilise the experience of another as well as its own. We might, indeed, compare it with the addition of a new sense, so greatly does it extend the sources of information. The communication between individuals is especially characteristic of vertebrates, and in the higher members of that subkingdom it plays a very great *rôle* in aiding the work of consciousness. In man, owing to articulate speech, the factor of communication has acquired a maximum importance. The value of language, our principal medium of communication, lies in its aiding the adjustment of the individual and the race to external reality. Human evolution is the continuation of animal evolution, and in both the dominant factor has been the increase of the resources available for consciousness.

In practical life it is convenient to distinguish the works of nature from the works of man, the "natural" from the "artificial." The biologist, on the contrary, must never allow himself to forget that man is a part of nature and that all his works are natural works. This is specially important for the present discussion, for otherwise we are likely to forget also that man is as completely subject to the necessity of adjustment to external reality as any other organism. From the biological standpoint, all the work of agriculture, of manufactures, of commerce and of government is a part of the work of consciousness to secure the needed adjustments. All science belongs to the same category as the teleological efforts of a jelly fish or lobster. It is work done at the command of consciousness to satisfy the needs of existence. The lesson of all this to us is that we should accustom ourselves to profit by our understanding of the trend of evolution, which, in the progress humanity makes, obeys the

same law of adaptation to objective reality which has controlled the history of animals. This view of the conditions of our existence puts science in its right place. As all sensations are symbols of external reality useful to guide organisms to teleological reactions, so is all science symbolic and similarly useful.

Nature never produces what to us seems a perfect organism, but only organisms which are provided with means of adjustment sufficient to accomplish the survival and perpetuation of the species. Man also is imperfect, but in the struggle for existence wins his way because his consciousness has greater resources than that of any other organism. His great power arises from his appreciation of evolution. His highest duty is to advance evolution, and this duty must be most strongly felt by those who accept the religious interpretation of life. The advancement of science is an obligation. To this view of the work of our Association I may safely claim the assent of all present.

The function of science is to extend our acquaintance with the objective world. The purpose of the American Association is not alone to increase the sum total of science, but equally also to preach by word and precept the value of truth, truth being the correct conscious symbol of the objective, by utilising which our purposeful reactions are improved. The most serious obstacle truth encounters is the prevalence of what I may call "doll ideas," by analogy with the material dolls with which children play. The child "makes believe" with the doll, knowing all the time its unreality, assigns to it hopes, passions, appetites; the child may feel the intensest sympathy with its doll, weep at its sorrows, laugh over its joys, yet know always that it is a mere inanimate, senseless doll. Adult men and women have ideas, with which they play make-believe; doll ideas, which they know are unreal, and yet they mourn sincerely over the adversities of their mental dolls, rejoice over their successes and fight for them with passion. Such doll ideas become mingled with the real and inextricably woven into the fabric of life. They are treated with the most earnest seriousness. Men will fight for them as a child will fight for its doll, not because it is property, but because it is sacred personality. So are doll ideas often made sacred and defended with fanaticism. Yet behind, in consciousness, is the sense of unreality, the disregarded admission of "making believe." Do not doll-ideas—pseudo-opinions—play a great *rôle* in human life? I think they do, and thinking so, deem it all the more imperative that you and others should teach the people the standard of science, the humble acknowledgment of reality. I wish an impulse towards this goal from our Association could be imparted to every man and woman in the country, and I hope the Association may continue to grow in number and power for long years to come, as it has grown in the last few years, so that it shall be a national, all-pervading influence serving the truth.

It seems to me inconceivable that the evolution of animals should have taken place as it actually has taken place, unless consciousness is a real factor and dominant. Accordingly, I hold that it actually affects the vital processes. There is, in my opinion, no possibility of avoiding the conclusion that consciousness stands in immediate causal relations with physiological processes. To say this is to abide by the facts, as at present known to us, and with the facts our conceptions must be made to accord.

The thought which I wish to emphasise is the importance for the future investigation of consciousness of separating the study of what it does from the study of what it is. The latter study is recondite, metaphysical, and carries us far beyond the limits of verifiable human knowledge. The former study is open to us and offers opportunities to science, but it has hitherto been almost completely neglected. Biology has now to redeem itself by effectual researches on consciousness. On the adequate prosecution of such researches we base great hopes.

Before I close, permit me a few words concerning the relations of consciousness to the body, to the living substance through which it manifests itself. It is intimately linked to protoplasm. Probably no question is so profoundly interesting to all mankind as the old question, What is the relation of the mind to the body? It is a question which has been stated in many forms and from many points of view, but the essential object of the question is always the same, to ask whether consciousness is a function of living matter or something discrete and not physical or material.

Throughout this address consciousness has been viewed as a device to regulate the actions of the organism so as to accomplish purposes which on the whole are useful to the organism, and accordingly we have termed its function teleological. If this view is correct, it accounts for the limitations of consciousness, its mechanical mode of work, its precision and definiteness of action, for, of course, unless consciousness is orderly and obeys laws it cannot be of use to the organism, but, on the contrary, it would be harmful, and conscious animals would have ceased long ago to survive. The very fact that consciousness is of such high value in the bionomy of an animal renders it obvious that it must be subject to law. Accordingly it appears to us regulated as do the functions of protoplasm, hence to certain modern thinkers it presents itself as a function of protoplasm, or, as it may be better stated, as a state or condition of protoplasm.

The internal evidence of consciousness, however, is against this view and presents to us conscious actions as depending upon the consciousness. As before stated, I believe this evidence must be accepted. Now all the sensations of consciousness are derived from physical force, and all the acts of consciousness are manifested through physical force, hence if it has any real power consciousness must be able to change the form of energy. Unless we accept this doctrine we must give up all belief in free-will and adopt the automaton theory of life. Is not the more reasonable explanation that which is based upon all the contents of our consciousness rather than that which we can draw only by discarding the internal evidence which consciousness brings us? The hypothesis which I offer for your consideration is this:—

Consciousness has the power to change the form of energy, and is neither a form of energy nor a state of protoplasm.

By this hypothesis there are two fundamentally different things in the universe—force and consciousness. You ask why I do not say three, and add matter? My answer is that we do not have, and never have had, any evidence whatever that matter exists. All our sensations are caused by force, and by force only, so that the biologist can say that our senses bring no evidence of matter. The concept "matter" is an irrational transfer of notions derived from the gross molar world of the senses to the molecular world. Faraday long ago pointed out that nothing was gained and much lost by the hypothesis of material atoms, and his position seems to me impregnable. It would be a great contribution to science to kill off the hypothesis of matter as distinct from force.

To conclude, the universe consists of force and consciousness. As consciousness by our hypothesis can initiate the change of the form of energy, it may be that without consciousness the universe would come to absolute rest. Since I close with a bold speculation, let my last words recall to you that my text is:—Investigate consciousness by comparative observation. Only from observation can we know. Correct, intelligent, exhaustive observation is our goal. When we reach it, human science will be completed.

NOTES.

WE understand from recent Queensland newspapers that it has been determined to abolish the Weather Bureau of that colony as from the 30th ult., and that the services of Mr. C. L. Wragge and his special staff have been dispensed with. In a letter addressed by the Premier of Queensland to the Federal Prime Minister it is pointed out that this apparently retrograde step is owing to the urgent necessity for reducing in every branch of the public service the estimates of expenditure of the State, and that it is one of the "most unfortunate" results of the large deficit in the revenue, brought about by drought and other causes. Prior to federation, the Weather Bureau formed part of the Post and Telegraph Department of Queensland, and all telegrams and correspondence passed free. But during the last fifteen months the Federal Government has charged for these communications at the rate of about 4000*l.* a year, which expense cannot be borne any longer by the Queensland Government. The Premier writes that he feels sure the States in general will welcome any reasonable suggestions for a continuance of the work of the Bureau under federal control; we may therefore hope that the existing instruments and stations will be utilised, as far as practicable, in the interest of meteoro-